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Digital Mapping, Charting, and Geodesy Analysis Program: Initial Technical Review of Raster Product Format

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13. ABSTRACT *(Maximum 200 words)*

Rounding out the Defense Mapping Agency's (DMA) effort for a raster standard to complement the existing Vector Product Format and proposed Text Product Standard, the Raster Product Format (RPF), is the proposed format for accommodating raster data. The Naval Research Laboratory's Digital Mapping, Charting, and Analysis Program (DMAP) has been requested by DMA (via N096) to establish the usefulness of such a standard for naval purposes. In its technical review, DMAP discusses the overall view of a raster standard and how the development of such a standard should proceed. The RPF, for example, should be modified to be compatible with already-existing standards. The suitability of RPF as it currently exists is also discussed by DMAP.

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Digital Mapping, Charting, and Geodesy Analysis Program Technical Review of Raster Product Format (RPF)

1.0 RPF Overview

The primary goal of the Raster Product Format (RPF) is to provide a common format to ease the interchange of raster data among producers and users. Typical raster images to be implemented in the RPF are scanned maps and images (basically, rectangular arrays of pixel values). Any related application software should be able to access data in the RPF without further manipulations or transformations.

The major components distinguishing RPF from its predecessor, Raster/Gridded Product Format (RGPF), are the omission of gridded products from the format and the implementation of National Imagery Transmission Format, Version 2.0 (NITF). The draft RPF on which this review is based is defined by three documents: *Raster Product Format* [4], *Registered Data Values for Raster Product Format* [5], and *Integration of Raster Product Format Files into the National Imagery Transmission Format* [3]. Additionally, an RPF prototype product, Compressed Equal Arc-Second Digitized Raster Graphics (CADRG), described in [2], is included as part of this review.

1.1 As a Stand-Alone Format

As a stand-alone format, the RPF would suffice as a structure for raster products. It is a comprehensive and well-designed format for geospatial image data. The adoption of NITF, as well as the omission of gridded products, was a clear enhancement over the RGPF. Only minor considerations would need to be addressed if the RPF were to be formally adopted (most of these comments are summarized in Appendix A).

1.2 As Part of a GGIS (Global Geospatial Information and Services) Concept

The fundamental approach of RPF offers minimal capability for supporting advanced data processing of raster data with other types of data, namely, vector data in the Vector Product Format (VPF) and text in the proposed Text Product Standard (TPS), or more specifically, with their associated metadata. Significant effort would be required by users to reformat RPF data to support its integrated processing with relational-based VPF databases.

RPF developed around the ARC tiling scheme developed for ADRG. While this type of approach to developing a standard is conventional, it will not adequately support the

move towards a Defense Mapping Agency (DMA) Global Geospatial Information and Services (GGIS) concept. For the GGIS initiative, the World Geographic Reference System (GEOREF) tiling scheme of VPF products will be utilized.

In a traditional Geographic Information System (GIS), the user is blind to the many rudimentary operations that must be undertaken to provide an appearance of merging gridded, raster, vector, and text data together to support common queries, overlays, and displays. Recently, the use of integrated data structures, which provide topological linkage between these data types, has become effective in supporting more advanced spatial data processing environments. The merger of relational data structures with object-oriented programming extensions provides the optimistic user with a myriad of choices for supporting fully integrated topologically based processing. Within such an environment, raster and vector datasets can more easily be georeferenced to relational tables of both meta and attribute data. To accomplish this type of seamless integration, DMA must utilize more advanced data structures that address combining data storage mechanisms for raster, gridded, vector, and text data. This utilization would require a move away from the current approach of developing a separate RPF to one which merges the raster data format with other standards like the current VPF and the proposed TPS.

In brief, RPF could not easily be used with multiple vector layers in a relational database management environment, a future relational/object-oriented combination, or a purely object-oriented environment, which are the directions that digital Mapping, Charting, and Geodesy will most likely move. The primary reasons are as follows:

i. RPF metadata are stored differently than currently accepted VPF metadata.

ii. Current RPF products use a different framing/tiling scheme than current VPF layers that will likely comprise the GGIS.

2.0 Related Formats/Standards

The RPF is closely associated, by the nature of its purpose, with two accepted formats/standards: Spatial Data Transfer Standard (SDTS) [8], a standard allowing ease of transfer of various spatial data, and the NITF [1], a standard for imagery transmission.

2.1 SDTS

Usage of SDTS becomes mandatory for Federal agencies on 15 February 1994. In its introduction, [8] states

> SDTS provides a solution to the problem of spatial (i.e., geographic and cartographic) data transfer from the conceptual level to the details of physical file encoding. Transfer of spatial data involves modeling spatial data concepts, data structures, and logical and physical file structures. To be useful, the data to be transferred must also be meaningful in terms of data content and data quality. SDTS addresses all of these aspects for both vector and raster data structures.

DMAP recommends that SDTS be further examined to determine its relationship to the RPF. Whereas SDTS is strictly concerned with data transfer (e.g., no tiling structure is employed by SDTS since it increases data structure complexity), its mandated use and application to raster image data should merit a reference as to how it could relate to the RPF. Also, the journal *Cartography and Geographic Information Systems*, Vol. 19, No. 5, 1992 is a special issue that focuses on SDTS and its requirements. In particular, the article [7] is especially recommended for review.

2.2 NITF

Conforming to NITF makes RPF products accessible to users on different platforms and more in line with DOD/IC interchange requirements but further from GGIS goals and interproduct compatibility (see disadvantage ii).

Some of the advantages of having NITF include the following:

i. NITF is one in the group of standards adopted for the GGIS initiative. NITF was designed to provide a common digital storage and interchange format across diverse platforms making it consistent with the intent of GGIS.

ii. NITF provides numerous user formatted data areas. One of the initial problems with the RGPF was that of storage of ancillary data (e.g., satellite imagery headers, alternate display parameters, etc.). NITF has several areas where tagged user fields of any format may be located.

iii. NITF provides a flexible format that allows multiple images in a single logical structure. The RPF format alone, which allows only a single image per file, could become clumsy if a future product required multiple images.

iv. NITF provides a known structure for which, presumably, software would be widely available to DMA users. Because several of the RPF image description tables have been placed alongside the image, some generic NITF software may be able to display the RPF image. This could be an advantage to the incidental user of the RPF format products.

Some of the disadvantages of having NITF include the following:

i. NITF, as with most additional software layers, carries an overhead penalty. There are many duplicate fields between the NITF and RPF formats, making storage requirements greater and the chances for data inconsistencies more likely.

ii. NITF worsens the metadata access problems between RPF and VPF. NITF adds another data format that software has to manage in order to gain information on the contents of an RPF product.

iii. Inserting the RPF fields into NITF could probably be better done by redesigning the RPF using existing NITF fields where possible, as was done with Digital Point-Positioning Databases. This would avoid the duplication of fields while maintaining NITF's flexibility and character-based format.

3.0 Tiling

The fundamental approach to tiling in the RPF is to build upon parts of the ARC tiling/zoning scheme developed for ADRG. The specification clearly uses the same zones, but it is unclear if RPF will continue using the global tiling scheme used in ADRG (padding with black pixels to form images whose dimensions are multiples of 128 pixels, specifying projections for the polar and nonpolar zones, specifying projection origins, etc.). Since [5] contains registered values for many projections, whereas ADRG allows for only two, the specification is confusing. Nevertheless, the

usage of the ARC zones hinders interoperability with VPF, in which most products employ the GEOREF tiling scheme.

Further adding to the confusion regarding tiling is the example given on p. 20, Section 5.1.2 in [4]. A typical map [frame file] shall be 256 x 256 pixels, which is clearly a multiple of 128 (i.e., agrees with ADRG). A typical frame, in turn, will be composed of a 6 x 6 matrix of subframes. These dimensions imply that a subframe does not have an integral number of pixels for its dimension (6 does not divide 256), unless of course variable subframe sizes are allowed.

The RPF should clearly define its tiling scheme and any deviations from ARC this scheme may have. If RPF is accepting the ARC/ADRG approach as standard, then reasons for its selection over GEOREF should be provided. (Note: GEOREF, for all practical purposes, appears superior to ARC/ADRG: it allows for a variety of tile sizes, its addressing scheme is sufficiently compact to permit a combination of four letters and four numbers to reference any point on the earth to within 1 nautical mile, which allows for an efficient file-naming scheme. RPF file naming relies on codes from producers.)

4.0 Imagery (Non-Chart Data)

One of the initial concerns with the RPF was its capability of handling a variety of remotely sensed multispectral imagery (MSI), taken from such sensors as LANDSAT TM, SPOT, and AVIRIS. Although prototypes of CADRG imagery were available in the RPF, no MSI prototypes were evaluated for this review. However, the RPF appears to provide an acceptable format for MSI. The NITF, with its tagged data extensions, allows storage of information not expressly defined in the format (e.g., sun angle at time of collection of TM image).

Although RPF fields exist to adequately describe such attributes as dimensions of the data, areal coverage, and spatial resolution, a remaining concern is the fact that some users may want raw unprocessed data, where little or no corrections have been applied. For example, LANDSAT TM is available in a variety of map-oriented formats (system corrected, precision corrected, terrain corrected), georeferenced to the user's specification of scale, datum, projection, etc. However, the possibility of obtaining raw TM data still exists.

While the RPF allows for the capability of storage of nongeorectified data, its strong connection with the ARC zoning scheme (for filename extensions, etc.) may lead to confusion. An alternative approach would be to eliminate any dependence on the ARC

scheme, or state fully the relationship of RPF with ARC and why this relationship is not prohibitive, if indeed that is the case.

5.0 CADRG Prototype 3.0 Comments

In comparing the CADRG specification to the RPF several discrepancies were found. These are listed in Appendix B.

6.0 Key Issues

Summarized below are the key points made in this review:

1. The concept of RPF tiling should be clarified, specifically as it relates to VPF products that will likely populate the GGIS.

2. "Nonchart" imagery such as remotely sensed data (e.g., LANDSAT TM map-oriented) needs to be given more detailed treatment in the specification.

3. Unprocessed imagery (not georeferenced to a particular datum or chart) should be given more attention, as some users of raster data prefer imagery uncorrupted by transformations, stretching, etc. The choice of ARC zones and chart series used in file naming may cause confusion.

4. SDTS should be reviewed as a part of the RPF.

5. Although not discussed in this review, the issue of gridded data remains unresolved.

6. The comments and corrections listed in Appendix A should be addressed in the RPF documents before the raster standard is upgraded.

7. The CADRG specification and the RPF disagree as noted in Appendix B.

7.0 Recommendations

This version of a raster product standard should not be accepted in its present form. The primary reason is its inability to adequately complement advanced relational (or object-oriented) database environments.

The design of the RPF format should be reconsidered from the standpoint of interoperability with VPF products and with database management systems (DBMS) in general. DMA has recently expended significant resources developing VPF as a georelational database structure. VPF data products will be readily imported into GISs. The metadata and attribute data contained in VPF are readily imported into relational database management systems (RDBMS). Once imported, the data may be fused with other data and exploited using the power of the RDBMS and GIS.

A new raster product standard should be constructed around the following concepts:

1. Store all metadata in a VPF-type format that RDBMS can exploit. The use of such relational tables for RPF metadata would allow raster and vector data to be queried in a consistent manner.

2. Introduce new standardization of storage for raster data sets only at the actual level where current VPF standardization becomes unsuitable. For example, the VPF table format may be useful in a raster standard. The VPF concepts of library and coverage may also apply. A common tiling scheme may be agreed upon for both the VPF and RPF.

Finally, an integrated spatial data standard should be pursued long term to combine raster, gridded, text, and vector data together for optimum GIS and RDBMS exploitation. This approach is different from the original DMA plan to develop three overall standards for data (raster, vector, text) and is especially recommended now with the advent of GGIS.

8.0 Acknowledgments

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9.0 References

[1] Defense Information Systems Agency, *Military Standard National Imagery Transmission Format (Version 2.0) for the National Imagery Transmission Format Standard*, MIL-STD-2500, 18 June 1993.

[2] Defense Mapping Agency, *Draft Military Specification Compressed ARC Digitized Raster Graphics (CADRG)*, MIL-C-89038, 1 July 1993.

[3] Defense Mapping Agency, *Draft Military Standard Integration of Raster Product Format Files into the National Imagery Transmission Format*, MIL-STD-2411-2, 22 December 1993.

[4] Defense Mapping Agency, *Draft Military Standard Raster Product Format*, MIL-STD-2411, 9 November 1993.

[5] Defense Mapping Agency, *Draft Military Standard Registered Data Values for Raster Product Format*, MIL-STD-2411-1, 15 November 1993.

[6] Fegeas, Robin G., et al. "An Overview of FIPS 173, The Spatial Data Transfer Standard," *Cartography and Geographic Information Systems*, Vol. 19, No. 5, 1992, pp. 278-293.

[7] Greenlee, David D. "Developing a Raster Profile for the Spatial Data Transfer Standard," *Cartography and Geographic Information Systems*, Vol. 19, No. 5, 1992, pp. 300-302.

[8] National Institute of Standards and Technology. 28 August 1992. *Federal Information Processing Standard Publication 173 (Spatial Data Transfer Standard)*. U.S. Department of Commerce.

[9] Wortman, Kathryn. "The Spatial Data Transfer Standard (FIPS 173): A Management Perspective," *Cartography and Geographic Information Systems*, Vol. 19, No. 5, 1992, pp. 294-295.

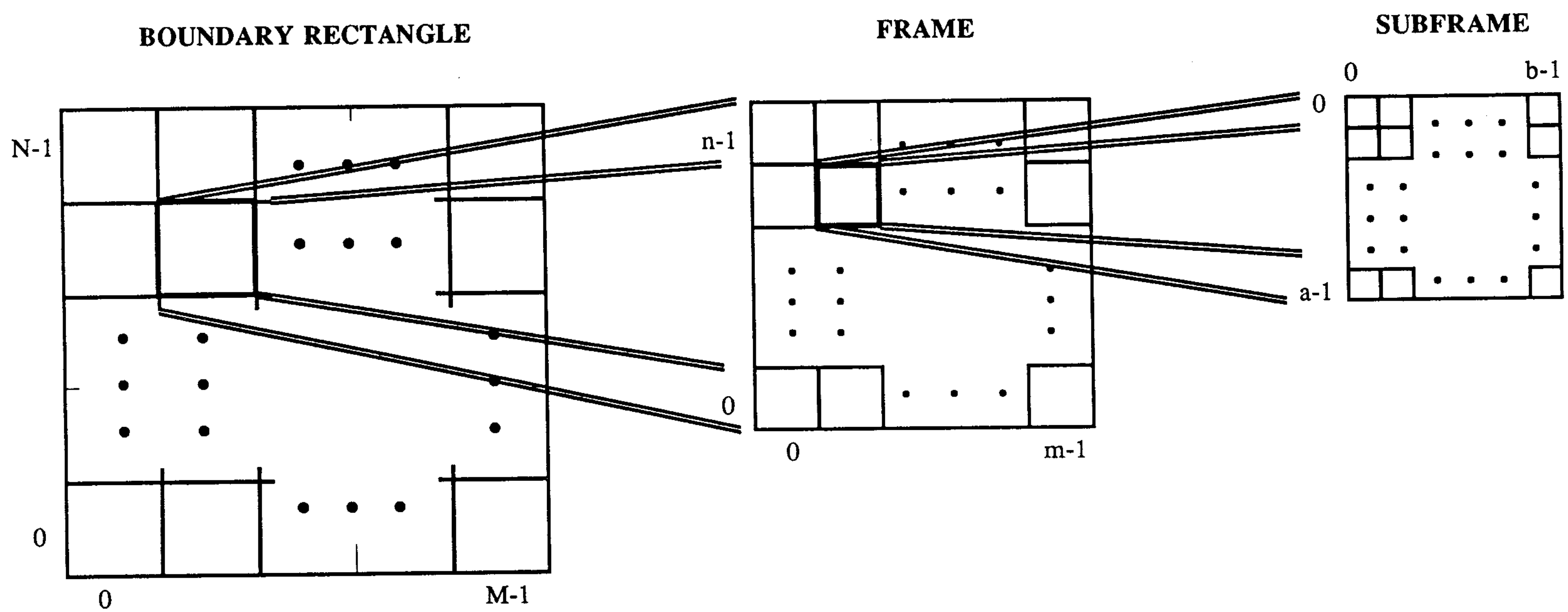

Figure 1. Example diagram showing boundary rectangle, frame, and subframe referencing

Appendix A. Comments on References [4], [5], and [3].

[4] MIL-STD-2411

p. 7 There are references throughout the document to gridded products, which are no longer part of the RPF. One example is on p. 7, Section 4.a. More are located on p. 20, Section 5.1.1 (elevation post values), and p. 28, Section 5.1.9.

p. 7 *Arc* should be *ARC* ("Equal Arc-Second Raster/Chart Map").

p. 12 In Section 4.4.2.1, move "Note: ^ denotes exponentiation." above the first occurrence of the "^" symbol. Also, be consistent with subtraction spacing: second equation, S4.4.2.1, "B - 1."

p. 19 A decision should be made between <*chart* series and zone> or <*data* series and zone>. MIL-STD-2411-1 uses the latter.

p. 21 How does one distinguish between different boundary rectangles? This question is answered in the diagram on p. 31 (reference each boundary rectangle by the lat/long vertices), but this also needs to be mentioned in the text. Section 5.1.3 on p. 21 since should probably mention this detail, since that is where frame and subframe referencing is described.

p. 21 Different variables should be used to describe subframe size in sections 5.1.3.c.1 and 5.1.3.c.2 since N and M were used to describe frame size in 5.1.3.b.1 and 5.1.3.b.2. A figure (an example is given in Fig. 1) showing the way in which frames and subframes are referenced within boundary rectangles is recommended.

p. 21 Section 5.1.3.d: */image codes/s* should be */image code/s*

p. 22 Section 5.1.4: *RPF-comatible* should be *RPF-compatible*

p. 22 Section 5.1.4: *use* should be *uses*

p. 27 Section 5.1.8: *.c.5.1.8* should be *5.1.8*

p. 27 Section 5.1.8: *intented* should be *intended*

p. 27 In addition to the various <... record length> fields intended for backward compatibility, <header section length> should also be mentioned as intended for

backward compatibility. Moreover, in the logical element alphabetical listings later in the text, <section/component location record length> is not mentioned as being intended for backward compatibility. This needs to be corrected in the listings or the exception of this particular record length noted on p. 27.

p. 28 MIL-STD-2411-1 is still referred to as "the handbook" in Section 5.1.10. The title of that document has changed.

p. 30 Part of a sentence is left off in Section 5.2.1.b.2. See...?

p. 31 How does one determine a boundary rectangle? Is there a standard or logical method?

p. 35 Beginning on this page and throughout the remainder of this standard, references to MIL-STD-2411-1, Section 4 should be references to Section 5. In Section 5.2.1.d of the RPF standard, this reference error is found in the following elements: 5, 11, 12, 13, 43, 44, 45, 46, 51, 52, 53, and 58. In Section 5.2.2.c of the RPF standard, this reference error is found in the following elements: 3, 9, 13, 14, 20, 24, 79, 86, 89, 94, 95, and 96. In Section 5.2.3.d of the RPF standard, this reference error is found in the following elements: 4, 21, 22, and 23.

p. 35 Section 5.2.1.d.4: *[color index record* should be *[color index record]*

p. 35 Section 5.2.1.d.6: *pixels* should be *pixel*

p. 39 In (48), *lenght* should be *length.*

p. 41 In (6), section "TBD" should be resolved.

p. 46 In Fig 3, *[relateed images subsection]* should be *[related images subsection]*

p. 48 Beginning on this page, the numbering of [frame file] elements is incorrect. The following numbers are missing: (11), (12), (17), (23), (35), (78), and (85).

p. 56 Section 5.2.2.c: *(49)* and *(50)* should be *(92)* and *(93)*

p. 50 Section 5.2.2.c.33: *<hostogram* should be *<histogram*

p. 51 Section 5.2.2c(37) is missing ">" symbol: "<image code bit length"

p. 54 Section 5.2.2.c.75: *previously* should be *previous*

p. 54 Section 5.2.2.c.75: *field>* should be *field*

p. 55 Section 5.2.2c(83): the first sentence needs to be simplified into possibly two or more sentences.

p. 56 Section 5.2.2.c.87: *[replace/.update* should be *[replace/update*

p. 57 Section 5.2.2c(101)b is missing a ")" symbol.

p. 58 Section 5.2.2c(103)b is missing a ")" symbol.

p. 62 Section 5.2.2c(62) is missing the ending period.

p. 62 Section 5.2.3.d.12: *<hostogram* should be *<histogram*

[5] MIL-STD-2411-1

p. 7 Section 5.1.2: *define* should be *defines*

p. 7 Section 5.1.2.a: *in following* should be *in the following*

p. 11 Section 5.1.6: CDTED and DTED are gridded products and are not supported in RPF

p. 17 Specify that VQ stands for Vector Quantization in the given tables.

p. 26 Section 5.3.2.2: Why are datum codes allowed in the RPF? Horizontal datum is specified in MIL-STD-2411 as WGS 84.

p. 42 Section 5.4 *used* should be *use*

In general, this standard is well-organized and adequately fulfills its purpose as a companion standard to MIL-STD-2411.

[3] MIL-STD-2411-2

p. 6 In MIL-STD-2411, [rpf mask subsection] is actually divided up into two tables, [rpf subframe mask table] and [rpf transparency mask table]. To maintain consistency between the standards, it is recommended that the same headings be used in both documents.

p. 6 The ordering of the [rpf frame file] sections, although correct, differs from the ordering presented in MIL-STD-2411 on p. 40. The two orderings should be the same for consistency, as are the [rpf table of contents file] and [rpf external color/grayscale file.]

p. 7 What is meant by NITF *message* should be made more clearly in the standard.

p. 8 In Section 5.3, *[rpf component]* is mentioned in each of the tables. The standard needs to specifically state what is meant by this heading and which sections are included within it.

Appendix B. Comments on Reference [2] compliance with RPF.

1. Four fields under the heading [Mask subsection] should appear at the beginning of the [Image display parameters subheader]. These fields include

<all blocks present indicator>
<no transparent pixels present indicator>
<block sequence record length>
<transparency sequence record length>

2. The [Block mask table] and [Transparency mask table] should appear after all of the required header information in the [Image display parameters subheader].

3. The [Mask subsection] designation has been removed from the RPF format and should be removed from the CADRG specification.

4. File name case (upper/lower) should be consistent with the requirements of the platform. In UNIX, lower case is needed.

Appendix C. Acronyms.

ADRG	ARC Digitized Raster Graphics
CADRG	Compressed ARC Digitized Raster Graphics
DBMS	Database Management System
DMA	Defense Mapping Agency
DMAP	Digital Mapping, Charting, and Geodesy Analysis Program
DTED	Digital Terrain Elevation Data
GEOREF	World Geographic Reference System
GGIS	Global Geospatial Information and Services
GIS	Geographic Information System
MSI	Multispectral Imagery
NITF	National Imagery Transmission Format
RDBMS	Relational Database Management System
RGPF	Raster/Gridded Product Format
RPF	Raster Product Format
SMap	Scanned Map
TPS	Text Product Standard
VPF	Vector Product Format
WGS84	World Geodetic System 1984